Preliminary Study on Impact of Seed-row Place P Fertilizer on Emergence and Yield of 10 Crops Under Controlled Environment Conditons

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INTRODUCTION

Seed-placed phosphorus fertilization is usually one of the most efficient means for applying phosphorus, which normally results in better response than surface-applied with incorporation. Lauzon and Miller (1997) reported that early season corn and soybean shoot-P concentrations are increased with increasing soil test P and were increased with seed-placed P regardless of soil test P. However, the germination and emergence of crop seeds can be reduced by seed-placed phosphate fertilizer as some crop seeds are especially sensitive to fertilizer salts. Providing guidelines for maximum safe rates of fertilizer P with seed is essential for achieving maximum benefit from seed-row placement of P fertilizer.

General guidelines for maximum safe rates of seed-row P have been developed on the prairies for cereals, canola, flax, fababean, lentil, and pea for a narrow (six to seven) inch row spacing. The diversity of crops grown in Saskatchewan now has increased, and there is a need for information to create similar guidelines for other crops that have become popular such as canaryseed, mustard, chickpea, dry beans (pinto beans) as well as forages including alfalfa and brome grass. There is also a need to examine tolerance for the low seed-bed disturbance configurations that now commonly operate on row spacings wider than 6 to 7 inches.

The objective of this study is to determine how seed-row placed P at five rates influences germination, emergence, early plant growth for six crops with limited information: canary seed, mustard, chickpea, pinto bean, alfalfa and bromegrass in comparison to four crops with considerable research information available: wheat, canola, flax & pea using an opener-row spacing configuration (10% seed bed utilization) typical of today's low disturbance direct seeding equipment.

MATERIALS AND METHODS

Soil, Fertilizer and Crop Seeds

The soil used in this study was collected at a depth of 0-15 cm in May of 2004 from a field in the Brown soil zone in south-central Saskatchewan near Mawer, where the soil is mapped as Haverhill association of loamy texture. The field had never received phosphorus fertilizer and had been in alfalfa for the last 10 years. After collection, the soil after collecting was mixed thoroughly in a soil mixer and stored in field-moist condition before use. For measuring basic soil properties, a sample was collected from the mixed soil, and then air-dried, crushed, passed through 2-mm sieve and stored at room temperature. Texture was estimated by hand. Electrical conductivity (EC) and pH were

measured using 1:1 soil:water suspension. Organic C was measured using Leco carbon analyzer. Available P was extracted by modified Kelowna method (Qian at al., 1994). Selected soil characteristics are summarized in Table 1.

Table 1. Some characteristics of the soil for seed-placed P evaluation.

Soil	pH	EC $mS\ cm^{-1}$	Texture	Organic C $g\ kg^{-1}$	Available P* $kg\ ha^{-1}$
Haverhill	7.4	1.04	loamy	20.8	18.0

*measured by modified Kelowna method

The fertilizer phosphorus source used was commercial fertilizer grade monoammonium phosphate (12-51-0). Ten crops were chosen for this study: hard red spring wheat, argentine canola, yellow peas, flax, canaryseed, oriental mustard, kabuli chickpea, pinto bean, alfalfa and brome grass. Seeds of the ten crops were collected at the same time. The crops were placed into two categories: Crops with better established responses to P fertilization (Class 1) and Crops with limited information (Class 2) as shown in Table 2.

Table 2. The ten crops tested in the study

Crop	Variety	Seed Rate $kg\ ha^{-1}$
(1) With better established responses:		
HR Spring Wheat	Prodigy	84
Argentine Canola OP non HT	Sprint	6
Yellow Pea	Carneval	180
Flax	CDC Valor	35
(2) With limited information:		
Canaryseed	Common Itchless	40
Oriental Mustard	Cutlass	11
Kabuli Chickpea	Xena	140
Pinto Bean	Pintium	114
Alfalfa	Beaver	10
Bromegrass	Knowles	40

Growth Chamber Study

Mixed soil was placed into flats approximately one meter long, 15 cm wide and 15 cm deep. The soil added to the flats was field-moist and further water was added to bring the soil to field capacity. There are five rates of fertilizer treatments, 0, 10, 20, 30, 40 kg P_2O_5 ha^{-1} with four replications. A seeding tool was manufactured to simulate a low-disturbance knife or hoe type opener with a seed bed utilization of 10% (1 inch spread and 10 inch row spacing) and on-row packing. This tool was used to place the seed at the appropriate depth along with monoammonium phosphate fertilizer. Rows of approximately 0.5 meters in length were created in the flats to provide a replicate for each crop and P fertilizer rate.

A period of four weeks following seeding and fertilizing was set for assessing seed emergence and plant growth. Emergence counts were made once every 3-5 days after planting. The data in Table 3 and 4 is the total emergence after 20 days. The flats of soil were kept near field capacity by surface watering once every day or 2 or 3 days as required to simulate rainfall. However, high airflow in the chambers was used to simulated drying in between watering as would occur in the field. Growth chamber conditions were 15ºC temperature with 18 hour day length and 6 hour night period. After 4 weeks, the above ground portions of the plants in the flat were harvested. The plants were then dried, and weighed for dry matter yield determination.

RESULTS & DISCUSSION

Effect of P Fertilizer Rate on Emergence Counts

There was no negative impact of over the range of ratios examined seed-placed P on emergence of wheat, canola, flax, canary seed, pinto bean, or chickpea, but a negative effect was observed at rates above 10 kg P_2O_5 ha^{-1} for yellow pea and alfalfa, 20 kg P_2O_5 ha^{-1} for mustard, and 40 kg P_2O_5 ha^{-1} for bromegrass (Tables 3 and 4).

Table 3. Emergence as affected by different rates of P fertilizer for wheat, canary, canola, mustard and flax

Rate of fertilizer	Wheat		Canary		Canola		Mustard		Flax	
	Counts	% E*	Counts	% E*	Counts	% E*	Counts	% E*	Counts	% E*
kg P_2O_5 ha^{-1}		%		%		%		%		%
0	11.8a	98a	20.5a	93a	11.5a	96a	9.3a	62a	9.3a	46a
10	11.5a	96a	18.3b	83b	11.5a	96a	7.7a	51a	9.0a	45a
20	11.3a	94a	19.0a	86ab	10.6a	88a	7.8a	52a	9.3a	47a
30	11.5a	96a	18.0b	82b	11.3a	94a	5.3b	35b	10.3a	51a
40	11.3a	94a	19.3ab	88ab	11.3a	94a	5.0b	33b	8.5a	43a

For each fertilizer source, means in columns followed by a different letter are significantly different at $p < 0.05$.
* %E (% Emergence) refers to % of planted seeds that emerged over 20 days

The high sensitivity of yellow peas to seed placed P has been documented previously. Of interest is the low tolerance of mustard, bromegrass and alfalfa. The canola and flax was more tolerant of seed-placed P than expected. However, caution must be used in interpreting these results. In the growth chamber, while some moisture stress through soil drying is simulated, additional stresses that may occur in the field such as disease, low seed vigor etc. are not reflected in the trial. As well, this experiment only evaluates seed-placed MAP alone, not in combination with some seed-placed N and K as may be used in the field.

Table 4. Emergence as affected by different rate of P fertilizer for bromegrass, alfalfa, pinto bean, chickpea and yellow pea

Rate of fertilizer	Bromegrass		Alfalfa		Pinto bean		Chickpea		Yellow pea	
	Counts	% E*	Counts	% E*	Counts	% E*	Counts	% E*	Counts	% E*
kg P_2O_5 ha^{-1}		%		%		%		%		%
0	15.0a	50a	14.8a	74a	6.5a	81a	5.0a	63a	7.3a	91a
10	14.0ab	47ab	15.5a	78a	6.0a	75a	4.8a	59a	7.5a	94a
20	13.3ab	44ab	12.3b	61b	6.3a	78a	4.8a	59a	5.0b	63b
30	14.3a	48a	10.5b	53b	7.0a	88a	4.0a	50a	4.3b	53b
40	7.8b	26b	10.3b	51b	6.0a	75a	4.5a	56a	4.0b	50b

For each fertilizer source, means in columns followed by a different letter are significantly different at $p < 0.05$.
* %E (% Emergence) refers to % of planted seeds that emerged over 20 days

Effect of P Fertilizer Rate on Plant Dry Matter Yield

Table 5. Dry matter yield (4 weeks after emergence) as affected by 5 different rate of seed-placed P fertilizer

Rate of fertilizer	Wheat		Canary		Canola		Mustard		Flax	
	Total	/In.P*	Total	/In.P*	Total	/In.P*	Total	/In.P*	Total	/In.P*
kg P_2O_5 ha^{-1}	g	mg	g	mg	g	mg	g	mg	g	mg
0	0.87a	74a	0.33a	16a	0.97a	84a	0.84a	89a	0.18a	19a
10	1.02a	88ab	0.31a	17ab	1.21abc	105ab	0.73a	95a	0.17a	18a
20	1.06a	95bc	0.39ab	21bc	1.16ab	110ab	0.92a	118a	0.19a	22ab
30	1.12ab	97bc	0.39ab	22c	1.49c	134b	0.67a	135a	0.28b	27bc
40	1.21b	108c	0.44b	23c	1.38bc	124b	0.66a	137a	0.27b	32c

For each fertilizer source, means in columns followed by a different letter are significantly different at $p < 0.05$.
*/In.P = mean weight of individual plants in each treatment

Good yield response in the first 4 weeks of growth to the seed-placed P was achieved in the crops up to the point where injury was observed in the mustard, bromegrass, alfalfa and pea (Tables 5 and 6). In the case of bromegrass, dry matter yield at rate of 40 kg P ha-1 dropped back to a similar value to that with no P addition, and is explained as a result of injury to the stand (Table 4). A similar reason explains the negative response trend in the treatments of mustard and yellow pea to the seed-placed P (Tables 5 and 6), as injury to the stand was observed in these crops at higher rate of P fertilizer (Tables 3 and 4). With the exception of chickpea, pinto bean and mustard, all crops responded significantly in early growth to seed-placed P with responses in sensitive crops limited by injury at high rates.

Table 6. Dry matter yield (4 weeks after emergence) as affected by 5 different rates of seed-placed P fertilizer.

Rate of	Bromegrass		Alfalfa		Pinto bean		Chickpea		Yellow pea	
fertilizer	Total	/In.P*	Total	/In.P*	Total	/In.P*	Total	/In.P*	Total	/In.P*
kg P_2O_5 ha^{-1}	g	mg	g	mg	g	mg	g	mg	g	mg
0	0.08a	5a	0.20a	14a	1.19a	184 a	0.78a	158a	0.67ab	93a
10	0.24b	18b	0.36c	23ab	1.18a	193a	0.86a	143a	0.71b	95a
20	0.18ab	15ab	0.32bc	26b	1.24a	199a	0.65a	131a	0.44a	96a
30	0.25b	17b	0.31abc	30b	1.44a	208a	0.57a	127a	0.44a	108a
40	0.09a	12a	0.23ab	22ab	1.34a	223a	0.76a	164a	0.44a	113a

For each fertilizer source, means in columns followed by a different letter are significantly different at $p < 0.05$.
*/In.P = mean weight of individual plants in each treatment

CONCLUSION

The majority of crops tested in the growth chamber showed no negative impact on seed germination and emergence with seed-placed P fertilizer at rates of 10 to 20 kg P_2O_5 ha^{-1}. Further testing of injury thresholds under different soil conditions (higher rates, varied moisture) & with controlled released P fertilizers is planned. In the soil used, some seed-placed P appeared useful in promoting early growth in nearly all crops tested. At 20 kg P_2O_5 ha^{-1} and above some injury was noted with peas, alfalfa, mustard and bromegrass.

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